THE CLAIMS

We claim:

1. A single-camera system for monitoring the movement of a striking instrument that impacts with an object comprising:

(a) a single camera unit having a light sensitive panel that is capable of being focused on a field of view through which the striking instrument passes prior to striking the object, wherein said single camera unit is capable of shuttering or gating at least two times as the striking instrument and object pass through the field of view;

(b) three or more contrasting areas on the striking instrument and one or more contrasting areas on the object, said areas positioned so that light emitting therefrom reaches said light sensitive panels to form images thereon and create image signals when the camera shutters are open;

(c) an image analyzer capable of discriminating between the striking instrument contrasting areas and the object contrasting areas and determining the conditions of the path and orientation of the instrument through the field; and

(d) wherein the striking instrument has a striking face, and wherein the striking instrument is calibrated such that the single-camera system is capable of identifying the position and orientation of the striking face from the striking instrument contrasting areas.

2. The system of claim 1, wherein the striking instrument is calibrated such that the spatial location of the contrasting areas are known relative to the geometric center of the striking face.

3. The system of claim 1, wherein the striking instrument is calibrated such that the body coordinates of the striking instrument are known relative to the striking instrument contrasting areas.

4. The system of claim 1, wherein the striking instrument is calibrated with a priori knowledge of the spatial locations of the striking instrument contrasting areas.

5. The system of claim 1, further comprising a calibration fixture having a plurality of contrasting areas, wherein the three-dimensional positions of the calibration fixture contrasting areas are known relative to each other

6. The system of claim 1, further comprising a calibration attachment having a plurality of contrasting areas, wherein the calibration attachment is capable of being disposed on the striking face, and wherein the position of at least one contrasting area of the calibration fixture is known relative to the striking face when the calibration attachment is disposed on the striking face.

7. The system of claim 1, wherein the single camera unit is configured to capture at least one image of the striking instrument when it is within about 2 inches or less from the object..

8. The system of claim 7, wherein the single camera unit is configured to capture at least one image of the striking instrument when it is within about 1 inch or less from the object.

8. The system of claim 1, further comprising an electronic light source that emits light in two flashes onto the instrument and object.

9. The system of claim 1, wherein the striking instrument has four contrasting areas and the object has six contrasting areas.

10. The system of claim 1, wherein the instrument is a golf club comprising a club head and a club face wherein the object is a golf ball, and wherein the image analyzer is capable of determining the club head path and face orientation during a swing of the club.

11. The system of claim 10, wherein the golf club is a golf club driver or iron.

12. The system of claim 10, wherein the golf club is a putter.

13. The system of claim 10, wherein the image analyzer is capable of determining the location of impact of the golf ball on the club face.

14. The system of claim 13, wherein the accuracy of the image analyzer for determining the golf ball impact location is within 0.25 inch.

15. The system of claim 14, wherein the accuracy of the image analyzer for determining the golf ball impact location is within 0.10 inch.

16. The system of claim 13, wherein the accuracy of the image analyzer for determining the golf ball impact location is comparable to the accuracy of a 2-camera system.

17. The system of claim 10, wherein the image analyzer is capable of determining one or more of a droop angle, a loft angle, a face angle, a path angle, or an attack angle of the golf club.

18. The system of claim 17, wherein the accuracy of the image analyzer for determining the golf club droop angle, loft angle, face angle, path angle, or attack angle is within 3 degrees.

19. The system of claim 18, wherein the accuracy of the image analyzer for determining the golf club droop angle, loft angle, face angle, path angle, or attack angle is within 1 degree.

20. The system of claim 17, wherein the accuracy of the image analyzer for determining the golf club droop angle, loft angle, face angle, path angle, or attack angle is comparable to the accuracy of a 2-camera system.

21. The system of claim 10, wherein the image analyzer is capable of determining the club head velocity with an accuracy within 20 feet per second.

22. The system of claim 21, wherein the accuracy of the image analyzer for determining club head velocity is comparable to the accuracy of a 2-camera system.

23. The system of claim 1, wherein the single camera unit is capable of shuttering or gating at least three times as the striking instrument and object pass through the field of view.

24. The system of claim 1, further comprising a triggering unit for determining when the single camera captures an image of the striking instrument and object.

25. The system of claim 24, wherein the triggering unit comprises a light source, a reflector, and an optical sensor.

26. The system of claim 24, wherein the triggering unit comprises an ultrasonic emitter and receiver.

27. A method of monitoring the movement of a striking instrument that impacts with an object comprising the steps of:

(a) providing a single camera unit having a light sensitive panel that is capable of being focused on a first field of view;

(b) placing a striking instrument having a first plurality of contrasting areas within the first field of view of the single camera unit to provide a first perspective view of the striking instrument and first plurality of contrasting images;

(c) capturing a first image of the first perspective view of the striking instrument and first plurality of contrasting areas;

(d) providing a second perspective view of the striking instrument and first plurality of contrasting area;

(e) capturing a second image of the second perspective view of the striking instrument and first plurality of contrasting areas;

(f) analyzing the first plurality of contrasting areas in the first and second images of the striking instrument to determine their three-dimensional positions.

28. The method of claim 27, wherein the first perspective view of the striking instrument and first plurality of contrasting areas differs from the second perspective view of the striking instrument and first plurality of contrasting areas from about 5 to about 10 degrees.

29. The method of claim 28, wherein the step of providing a second perspective view of the striking instrument and first plurality of contrasting areas comprises repositioning the striking instrument.

30. The method of claim 29, wherein the step of providing a second perspective view of the striking instrument and first plurality of contrasting areas further comprises maintaining the first field of view of the camera.

31. The method of claim 27, further comprising the steps of:

providing a calibration fixture having a second plurality of contrasting areas, wherein the three-dimensional positions of the second plurality of contrasting areas on the calibration fixture are known relative to each other;

placing the calibration fixture within the first field of view of the single camera unit to provide a first perspective view of the calibration fixture and second plurality of contrasting area;

capturing a first image of the first perspective view of the calibration fixture and second plurality of contrasting areas;

providing a second perspective view of the calibration fixture and second plurality of contrasting areas;

capturing a second image of the second perspective view of the calibration fixture and second plurality of contrasting areas;

analyzing the second plurality of contrasting areas in the first and second images of the calibration fixture to create a three-dimensional global coordinate system.

32. The method of claim 31, wherein a first axis of the global coordinate system is parallel to gravity, a second axis of the global coordinate system is directed toward a target, and a third axis of the global coordinate system is orthogonal to the first and second axes.

33. The method of claim 31, wherein the steps of capturing the first image of the first perspective view of the striking instrument and capturing the first image of the first perspective view of the calibration fixture are performed at the same time.

34. The method of claim 27, further comprising the steps of:

providing a calibration attachment having a third plurality of contrasting areas, wherein the three-dimensional positions of the third plurality of contrasting areas on the calibration fixture are known relative to each other;

placing the calibration attachment on a striking face of the striking instrument so that the first and second captured images of the first and second perspective views of the striking instrument and first plurality of contrasting areas further comprise images of the third plurality of contrasting areas; and

removing the calibration attachment from the strking face.